Physics 457 Problem Set 6

Due in Class, February 21, 2005

Note: This short P.S. is due Monday February 21. There will be no class Feb 23. On March 9, I will had out the take–home midterm. It will be due at 5 PM on March 11.

$$|\pi^0>=\frac{1}{\sqrt{2}}(|u\bar{u}>-|d\bar{d}>) \quad |\eta>=\frac{1}{\sqrt{6}}(|u\bar{u}>+|d\bar{d}>-2|s\bar{s}>)$$

$$|\eta'>=\frac{1}{\sqrt{3}}(|u\bar{u}>+|d\bar{d}>+|s\bar{s}>)$$

1. Show that the η and η' are indeed orthogonal.

2. Consider the bound states of Charmonium with $n = 1$ and $n = 2$.
a.) List all of the possible states and their quantum numbers including J^{PC} and $n^{(2s+1)}l_j$. There are 2 $n = 1$ levels (singlet and triplet) and a total of five $n = 2$ levels.
b.) Identify the η_c (2980 MeV), J/ψ (3097 MeV), ψ (3685 MeV), χ_{c0} (3415 MeV), χ_{c0} (3510 MeV), and χ_{c0} (3556 MeV).

3 a.) Use the $\psi(2s)$ to $J\psi(1s)$ mass splitting to determine α_s.

$$\text{Assume} \quad V(r) = -\hbar c\frac{\alpha_s}{r}$$

Hint: The positronum energy levels, without hyperfine splitting, are given by

$$E_n = \frac{m_\mu c^2 \alpha_e^2}{2n^2}$$

where $\hbar c\alpha_e = ke^2$ and m_μ is the reduced mass $= m_e/2$ for positronium.
b.) What is the effective Bohr radius for Charmonium?

4. The SU(3) baryons are made up of u, d, and s quarks. Thus there are 27 combinations of quark flavors. These 27 combinations are grouped according to their symmetry under exchange of any two quarks into a symmetric decuplet (10 baryons), two groups of eight, and an antisymmetric singlet.

a.) Write down the SU(3) combination that corresponds to the antisymmetric singlet.

b.) What are the quantum numbers I and s of this baryon?

c.) Since the color component of the baryon wave function is always ANTISYMMETRIC, the rest of the wave function must be SYMMETRIC (i.e. $\psi_{space} \times \psi_{spin} \times \psi_{isospin}$. Assume an $l = 0, s$–state and describe the symmetry under isospin and spin.